Hastings Museum Publications.

No. 1.

THE ECONOMY

OF

BRITISH

HYDROID ZOOPHYTES

BY

PHILIP JAMES RUFFORD

F.G.S.

With "Notes on the Work of Mr. Rufford for the Hastings Museum"

By W. V. CRAKE, B.A.

ONE FULL PAGE PLATE
AND
ONE FIGURE

Price 6*d.*

Economy of BRITISH HYDROID ZOOPHYTES.

James Philip James

TABLE A.

Order I. **HYDROIDA.**

Sub-order I. ATHECATA.

Polypites naked—without receptacles.

Polypites stalked, branched, and terminal;
(CORYNIDÆ).

Sub-order II. THECAPHORA.

Polypites provided with horny receptacles.

a Polypites stalked and terminal;
(CAMPANULARIIDÆ).

b Polypites disposed on both sides of axis;
(SERTULARIIDÆ).

c Polypites disposed of on one side only of axis;
(PLUMULARIIDÆ).

P. J. R.

CORRIGENDA.

Page	6,	line	11	from	top,	for	**mesoglœa**	read	**mesoglæa.**
,,	7,	,,	7	,,	,,	,,	,,	,,	,,
,,	16,	,,	12	,,	,,	,,	**Specialised**	read	**Specialized.**
,,	27,	,,	14	,,	,,	,,	**sponges**	read	**Sponges.**
,,	29,	,,	10	,,	bottom,	,,	**coral polyps**	read	**Coral polyps.**

NOTES ON THE WORK OF MR. P. J. RUFFORD FOR THE HASTINGS MUSEUM.

In putting these notes together I feel I am performing an urgent duty, the more pressing since during Mr. Rufford's life his innate modesty kept him ever in the background, so that for many years the part which he took in promoting the Hastings Museum was scarcely understood, and his name in Hastings unknown outside a small circle of fellow workers.

Mr. Rufford's first connection with the Museum was through the sale of the effects of the late Mr. S. H. Beckles, F.R.S., F.G.S., in April, 1891.

The Museum Committee was then fully organised, and a grant had been obtained from the Committee for the purchase of specimens. I was fortunate enough to accidentally meet Mr. Rufford—not knowing him even by name—and seeing him interested in the collection which he was explaining to a boy by his side, I came up and spoke to him. From this chance acquaintance a friendship sprang up between myself and Mr. Rufford, which was fruitful of so much during the last ten years for myself and the Museum. I shall always look with pleasure upon those days, at the same time regretting that they are ended.

To return to the Beckles' sale. I then mentioned the position of the Museum Committee as purchaser; and Mr. Rufford gladly consented to give me his advice as to what to purchase.

The Beckles' sale was an important step in the history of the Museum, because a home had to be found for the purchases. The Brassey Institute second floor was granted by the Town Council, and a beginning was made. In the minutes of April 2nd, 1892, I find a vote of thanks was passed to Mr. Rufford for his valuable aid in selecting fossils at the Beckles' sale, and again reference is made in the minutes of November 2nd, 1891, to expenses voted for removal of geological remains from Cliff End, Fairlight, to the Brassey Institute. This referred to the Iguanodon foot-print sand-cast now at the Museum which he presented.

In October, 1891, the Rev. J. W. Tottenham gave his munificent gift of his private Museum to the Museum, and after the removal which was carried out by me, Mr. Rufford threw himself vigorously into the task of arranging the specimens. Geology and Conchology and kindred forms of life had his peculiar care. Conchology was well represented in the Tottenham collection.

At an early stage of the history of the Museum, the Bradnam collection of local fossils from the Town Hall formed part of the original nucleus, to this was added the Beckles' fossils, mostly from the Wealden strata. A strong reinforcement was now to be added to our local collection by the loan of Mr. Rufford's private collection, which being added to from time to time, has given a marked geological character to the Museum, and caused it to be respected by geologists and men of science who visit the town.

At the opening of the Museum in the Brassey Institute, on Tuesday, August 16th, 1892, I made a few remarks from the platform in which after mentioning donors and lenders I said, "I must now turn to those who have given what is perhaps as valuable as money—that is time and dearly-bought knowledge. I must in the first place mention Mr. P. Rufford, our Hastings geologist, a gentleman well known in the scientific world for his researches amongst our Wealden flora; this gentleman has given up nearly his entire time since the month of May to arranging our specimens, both geological and otherwise. As I have been intimately associated with him during the last few months I can say that our Museum could scarcely have taken shape without his single-minded enthusiasm for science."

Mr. Smith Woodward, representing the Geological Department of the British Museum, referred to the discoveries of Messrs. Charles Dawson and Philip Rufford in the Wealden strata, and stated there was evidence that very soon their work would surpass that of Gideon Mantell, the great Sussex geologist.

On November 17th, 1893, Mr. Rufford was unanimously elected a member of the Museum Committee, from which time he became one of its most useful and energetic members, identifying himself thoroughly with its interests, and sparing neither time or trouble in any work he might set himself to accomplish.

The collection, including a fine series of Mollusca, was partly the cause that Mr. Rufford directed his attention to this section of Natural History, and to further illustrate the section many shells were added by him. The fishermen took to him specimens which were usually thrown back into the sea after the day's dredging, and by this means a fine collection of Hydroids and Polyzoa was formed, to which the energies of his later years were specially directed. At one time an effort was made to start Aquaria in the Museum. Mr. Rufford did his share of the work with ability, but the difficulty of keeping the water fresh marred his efforts in this direction. It is not necessary to detail the quiet work which Mr. Rufford carried out during the years between 1893 and 1899, making descriptive labels and displaying specimens; the Museum tells its own tale. But mention must be made of the pictorial work of illustration which he carried out during this period with prints gathered from the British Museum Catalogue of his Wealden flora at the British Museum, and other kindred sources. This was an improvement on the usual methods of labelling, and one much encouraged by the Committee. A recognition of Mr. Rufford's services was made by the Committee during this period by the gift of a standard work on shells which Mr. Rufford much appreciated.

In June, 1899, Mr. Rufford finally presented to the Committee the results of his labours. The letter was brief which announced the gift, it contained this passage:

> "Dear Crake,
>
> Thanks for your note, it may be well to specify the collections which I have the pleasure to offer to the Museum as a gift, *viz.*:
>
> 1. The Geological Collection from the Wealden formation of Hastings and neighbourhood at the Museum up to the present date.
> 2. Local recent Sponges.
> 3. Local Hydroids.
> 4. Local Echinoderms.
> 5. Local Polyzoa.
> 6. Local Mollusca.
> 7. Land and Freshwater Mollusca. (Local and from other Districts British.)"

We now approach the last years of this life full of study and joy in the search of the hidden secrets of the earth. Since 1899, Mr. Rufford had been engaged in

work for the Victoria History of the Counties of England, work for a Continental Museum, and in writing and illustrating the catalogues published in this volume, which is elsewhere referred to, also he was busy in the illustration of the Polyzoa and Hydroids to place with his specimens referred to in this volume. In the work of the removal of the collection into its new home on the first floor of the Brassey Institute in 1900, no member of the Committee worked harder than Mr. Rufford.

In 1901 the idea was mooted in the Committee of forming a Marine Biological Station in connection with the Museum, and money was voted for the purchase of a trawl net. This had Mr. Rufford's hearty support and during the winter of 1901, he paid a visit to the Marine Biological Station at Naples, purchasing specimens and himself studying on the spot, and visiting the fishing grounds in the steam trawl of the Institution; this resulted in an addition to the treasures of the Hastings Museum of Mediterranean Medusæ, etc.

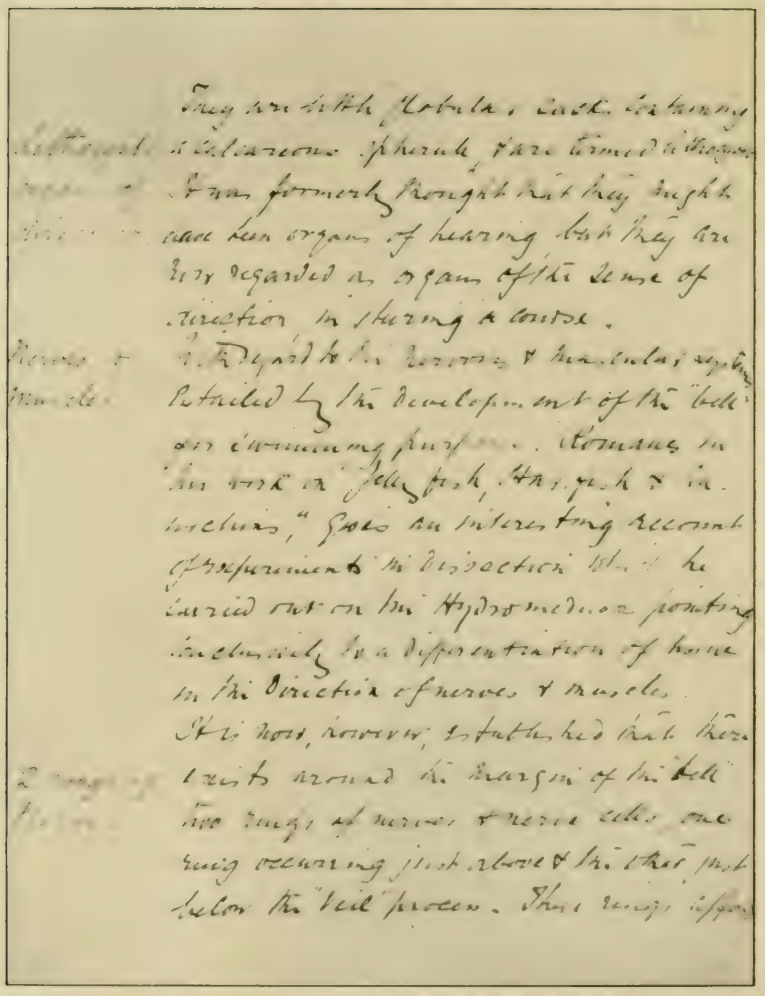
Mr. Rufford heartily aided me with the work of demonstrations to schools, and one of his last remarks to me was, that he was very pleased with the boys and girls of Tower Road Board School who were so interested in his last lecture on Geology, as he feared that he had dealt with matters rather above them.

The loss to the Museum in the coming years will be great, as they will no longer have the willing aid of Mr. Rufford, one of its best friends, with his large scientific reading and experience which he was ever ready to place at the service of all, and whose place it will be difficult to fill, as such services can only be rendered by one who has been long in sympathetic touch with the Institution in all its aims and endeavours.

W. V. CRAKE,

Hon. Sec. of the
Hastings & St. Leonards Museum Association.

ST. LEONARDS-ON-SEA.
1902.



E. C. *Photo.*

Folio 25 of

PHILIP JAMES RUFFORD'S MS.

See p. 20.

INTRODUCTION.

The Hydroids are mostly minute creatures and nearly all marine. The individual animal is termed a Polypite. They rank in organization just above the Sponges and below the Sea-anemones and Coral-polyps, to which they are closely allied.

Their structure is simple. A sack-like stomach, the only external aperture being the mouth, around which are arranged tentacles armed with poisonous darts or stinging cells, for the capture of prey.

The exterior of the body-wall is composed of a cellular layer (Ectoderm), some of the cells of which by extending and withdrawing lobes, perform the office of muscles, of which the Polypites proper are destitute. Within this is a delicate non-cellular membrane (Mesoglæa), the inner lining being composed of a layer of cells (Endoderm), which have the property of throwing out pseudopodia and flagella, by means of which circulation of the food particles is kept up. Some of these cells contain pigment and secrete a digestive fluid.

A very few Hydroids (ex. Hydra) lead a solitary existence. The great majority, however, by a plant-like process of continuous budding form colonies, the members of which are all organically connected, by reason of the

Buds or newly-formed Polypites not being detached. The connective parts are tubular, and allow the circulation of nutriment to all members of the colony.

In nearly all Hydroid colonies there is an outer horny cuticle (the Polypary), which in some cases does not clothe the Polypite itself, but only the connecting parts (the Cœnosarc). These naked Polypites form the division ATHECATA. Those in which the cuticle is prolonged to form protective cups or calycles constitute the division THECAPHORA.

The forms of the calycles vary, the rim being either plain, dentate, or with denticles which meet above the polypite and form a lid, or operculum.

The arrangement of the calycles on the stem and branches also differs. They may be either terminal (ex. *Campanularia*), biserial—opposite or alternate—(ex. *Sertularia*), or uniserial (exs. *S. Plumularia*, and *Antennularia*).

In one family of THECAPHORA there are found certain Amœboid bodies called Nematophores, more or less closely associated with the Polypites, and provided with darts and cuticular receptacles. The functions of these bodies are not known. It is possible that they are to be regarded as modified Polypites.

The principle of Alternation of Generation makes its first appearance in the Animal kingdom in this group. The Polypite is not

endowed with the function of sexual reproduction, but certain members produce *Special Buds* which are so endowed, the bearers of these buds becoming considerably modified in consequence. They are devoid of mouth or tentacles, and so do not concern themselves with procuring food. They are termed *Blastostyles*. The Special Reproductory Buds, in the lower forms of Hydroids, are liberated as Jelly-fishes, and disperse with their contained ova, to other parts. In the higher forms of Hydroids, these Reproductory Buds remain attached, setting free the ova *in situ*. Before liberation, the ovum undergoes segmentation, and produces, by a process of inversion, a central cavity—the future stomach. The embryo is termed a *Planule*, and is provided with cilia, by means of which it swims away, shortly attaches itself to some object, forms rootlets by the splitting up of the expanded base of attachment, and also develops a mouth and tentacles; it then becomes an ordinary Polypite, which, as growth proceeds, buds and forms a new colony.

P. J. R.

Fig. 1.

EXPLANATION OF FIG. 1.

Fig. 1. *Campanularia flexuosa*, Hincks.
(after Hincks.)

A. Natural size of colony.

B. A shoot enlarged, *bearing*

B.$^{/}$ Male reproductive capsules.

B.$^{//}$ Horny cup or receptacle.

B.$^{///}$ Polypite extended.

B.$^{////}$ Polypite retracted.

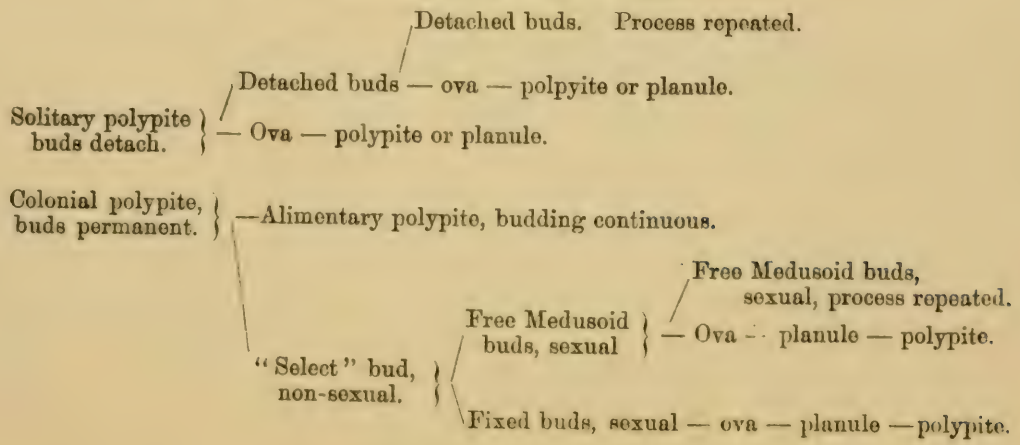
C. A shoot enlarged, *bearing*

C.$^{/}$ C.$^{/}$ Female or egg-capsules.

D. Cœnosarc, or connecting tissue which forms a tube.

TABLE B.

Showing the phases in reproduction (both by means of Budding and by Ova) in the solitary and in the colonial Hydroids.



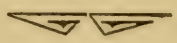
P. J. R.

PART I.

THE ECONOMY

— OF —

BRITISH HYDROID ZOOPHYTES.



General Remarks. "Things of beauty are generally small," says Aristotle, and the animals here represented, taken individually, are generally so minute that they would probably escape the notice of even the most enthusiastic searcher, did they only occur singly. They, however, have the habit in one of the phases of their existence—the fixed phase—of living collectively or in colonies, and in this form they may be discovered without much difficulty, in rock pools along the sea-shore; growing amidst the groves and spinneys of seaweed, or upon rocks, seaweed, and shells; they are also carried about on the coverings of living shell-fish, upon the backs

of Crustacea, and, in fact, upon many other creatures and objects. The shrimp trawlers' nets and boats, and the "rubbish" from the larger trawling vessels afford a rich source whence many rare forms may be obtained.

Hydroids six-ft. high. If, however, we were to look abroad in the Pacific, we should find fixed hydroids of the stature of a man, that is five or six feet high, but those which we are likely to meet with here will generally require the aid of a microscope, in order that their beauty, structure, habits, and remarkable life history may be observed. They are, however, particularly convenient for the microscopist, since they are of so transparent a nature that their internal structure and the operations of digestion and circulation—not to mention the elaborate and interesting stinging apparatus, which the animals use for overcoming their prey—can be readily observed. Some knowledge of each step of the animal kingdom is so necessary as affording the key to other parts, and for a proper comprehension of the whole, that even creatures so low in the scale of organization as the present group, should not be despised.

If they require any testimonial to recommend them to lovers of nature, it will be sufficient to say that they are very closely allied to the sea-anemones and the polyps, animals which form those exquisite structures the Corals.

Hydroids allied to the Sponges and Corals. In organization, the Hydroid animals (or polypites) are a step below these; but, on the other hand, they have as neighbours below them, though in a separate order, the anomalous group of animals, the Sponges.

"Zoophytes," so named by Linnæus. The group with which we are dealing, in common with others of like form and habit, was styled by Linnæus "Zoophytes," since, in consequence of the peculiarity they evince of forming tree-like growths and of the resemblance of the animals themselves to flowers, he regarded them as combining the natures of both plants and animals.

The cause and nature of these structures will be found a most interesting study. The polypites themselves can hardly be excelled in chaste beauty, being usually of a crystalline transparency sometimes picked out with

opaque white, or occasionally coloured pink, red, or orange. In the free phase (Medusa) the colouring is more vivid. In form the polypites are particularly elegant, and have only to be seen in their native element under the microscope, when their graceful movements will elicit the utmost admiration. Sometimes they are suggestive of palm trees with the crown of leaves fully expanded and gently swaying in the air; but the illusion is often quickly dispelled by the sudden closing of the fancied leaves, and the animal nature is revealed in the efforts of the polypite to secure some minute prey. When the food has passed into the stomach, the polypite expands again to its original beauty.

Leaving the æsthetic side of the subject for a moment (in which there is ample scope for gratification), we will turn to the scientific and get some idea of the grade of organization which the Hydroids hold, more especially with reference to their near neighbours in the animal kingdom.

Structure of Polypite. The Polypites, in the typical and fixed phase of their existence, are of very simple structure, and

the organs may be very briefly enumerated, *viz.*: a mouth, a stomach, and arms or tentacles with which to grasp their prey.

Stinging apparatus. In addition, the tentacles are provided with stinging darts, by means of which the animals overcome the struggles of their victims. These darts are very intesting structures, consisting of sacks more or less oval in form, containing long, coiled-up tubes, which are shot out like harpoons and penetrate or adhere to the quarry, which may be a minute worm or crustacean. These dart sacks are formed within a single cell.

Darts poisonous. All experiments and observations concerning these darts tend to show that poison is infused into the victim.

Body and Stomach sack-like. The body of the polypite may be compared with a sack or bag, the tentacles being arranged around the mouth or body.

Body wall consists of an inner and outer layer of Cells, with intermediate Membrane, Non-cellular. The whole body wall, including tentacles, consists of an outer layer of cells ("ectoderm") and an

inner layer of cells ("endoderm"). The latter differ in character from the former, the endoderm cells being capable of throwing out and withdrawing lobular processes ("pseudopodia"), and also others which are lash-like ("flagella"). These two layers of cells are separated by a fine membrane which differs from the middle layer ("mesoderm") of the sponges, and other groups, in being non-cellular and having no structure. It is known as the ("mesoglœa").

No through alimentary Canal. From the sack-like nature of the body, it will be noted that there exists no through alimentary canal such as we find foreshadowed in the higher Cœlenterates, and well-marked in the Echinoderms. The base of the body of the animal is used for attachment, or, as a surface by which to crawl.

No Organs of Sight, etc. This description applies to the polypite phase only of the Hydroid career, in which stage sense organs (organs of sight, etc.) such as are found in another—the Medusa—phase are wanting, as also certain "pores" which subserve excretion.

Nerves and Muscles. As regards nervous and muscular systems. In the tentacles, branching nerve-cells are found at the base of the ectoderm cells immediately in connection with a layer of single unstriped muscle filaments which lie between the ectoderm and the fine membrane (mesogloea), and, according to Parker and Haswell, are a derivative of the ectoderm, and may be regarded as a **Rudimentary Mesoderm**.

Colony-budding. Reference has been made to the peculiarity which specially characterises these Hydroids of forming groups or colonies, sometimes consisting of millions of creatures all in organic connection. These creatures, in common with many other of the lower animals, have the faculty of multiplying by means of budding, as it is termed. **Budding distinct from ova-production.** This method of reproduction is entirely distinct from that which takes place by means of ova, and may, perhaps, be tersely described as being produced by a simple inflation of the body wall (**budding an inflation of body wall**); such inflation when perfected by the formation of a mouth

and tentacles, constitutes a new individual. These buds, in some few species (Hydra, etc.) become detached, and like their parents, lead a solitary existence (**solitary polypites**), but, they also, and far more frequently, remain permanently connected with the parent growth, and by continuous budding produce branching plant-like structures. (**colony budding**).

"Cœnosarc," or connective parts. Between the parent creature and the young bud there is generally a new piece of stem formed which serves as a connective part joining the bud to the main stem. Probably this arrangement enables the young bud the better to obtain sufficient space for its development, the expansion of the tentacles, and the procurement of food. These intermediate portions which connect the polypites, are termed the Cœnosarc (meaning common flesh).

Protective resemblance to seaweeds. So nearly do these growths resemble seaweeds that the majority of observers mistake them for seaweeds. This close resemblance may therefore very probably serve as a protection against their enemies which might show less

partiality for seaweed than for animal diet, and so leave them undisturbed. Or it may have this effect—that the unwary and desirable quarry upon which they feed can approach them without fear or misgiving. However this may be, the resemblance is so striking, that even the student may now and then be deceived.

Budding, common in lower animals. The process of throwing out buds, which become detached, is common to other low forms of life besides the hydroids; but this peculiar habit of continuous permanent budding is nowhere else carried to so high a degree, except in the nearly allied Coral polyps,* and the somewhat distant Polyzoa.

The Skeleton. The polypary. Hydroid animals, being of such an extremely delicate and slender nature, demand, like most other animals, some support and protection in the form of a skeleton, either internal or external. That which the hydroids have developed, is in the form of an external

*For the purpose of distinction the hydroid animal is termed a Polypite; the coral animal a Polyp; and the polyzoa a Polypide. Polyp meaning "many footed," and the terminations, ide and ite, "like."

tube or casing composed of a horny substance called **Chitine.** This casing forms a somewhat loose jacket, and clothes in the more simple forms (ATHECATA) only those stem-like and branching portions (Cœnosarc) of the animal structure. In a few exceptional cases the skeleton is of carbonate of lime. These little horny branching growths are frequently cast upon the beach in tangled masses with seaweed and other objects. On examination with a lens, it will be generally found that the tubes are empty, the animal part having become decomposed. The entire horny envelope of the colony is called the polypary.

Polypite receptacles. In the higher forms of hydroids (THECAPHORA) this covering is more fully developed, and is expanded so as to form receptacles for the polypites themselves. These receptacles take the form of chalices or elegant cups, often with deeply scalloped margins and ringed stems. Those with the ornamented margins bear a close resemblance to the delicate little flower, the Hare-bell, and they have consequently been named "Campanulariidæ."

Receptacle door, or lid. In some cases, amongst the higher kinds, there are devices for closing the top of the receptacle by a lid of various forms, which is forced open when the animal emerges, and closes when it retires. The lid is either external or internal, the latter form being the higher development.

"Nematophores." Attention should also be called to certain peculiar bodies called "Nematophores" or "Guard-polypites," which are found on the stem and branches of the *Plumulariidæ*, and often closely associated with the polypites. They have been carefully studied by Allman, and appear to be a prolongation of the outer animal layer of the cœnosarc, and show the lobular movements peculiar to the lowest form of animal life, *viz.*, the amœba. **(Amœba-like character of Nematophore).** They may be readily watched in either *Plumularia* or *Aglaophenia*. In the latter they are found exceptionally distributed over the egg-case. Their functions are not fully understood. In some instances dart sacks are found in connection with them.

Formation of Bud. It has already been mentioned that each member of the hydroid community is formed by what has been described as an inflation of the body wall, which consists only of an inner and an outer layer of cells, and an intermediate membrane.

Hollow connection between parent and bud. This statement implies that there is a hollow connection between the alimentary cavity of the parent and the new bud, which allows the nutriment elaborated by the parent to be conveyed to the young bud for its nourishment. (**Circulation of nutriment.**) This step is repeated with every bud formed, so that it will be understood that a regular circulation of nutriment previously prepared in the stomach of each polypite, can be continued throughout the whole colony, and utilized by those members requiring it.

Circulation maintained by "Cilia." Each individual can either pass it at will into the common channel, or can itself draw upon it. The current of this material, passing up

and down the tubes, is maintained by means of cilia—minute hair-like processes, which by constant waving keep up the circulation.

Object of circulation. It may be thought that this common supply is unnecessary, that each member could find ample food for itself. But there are the immature buds; the intermediate parts of the structure, that is, the cœnosarc, with the Nematophores; and, more important than all, certain other individuals yet to be described, which in consequence of special and important duties devolving upon them, are in many cases rendered incapable of obtaining food for themselves.

A brief description of these members of the colony will follow.

Dispersal. It will be evident that if multiplication of the individual be restricted to the method already described, (*viz.*, permanent budding), dispersal of the species could not take place. Nature has therefore allotted to certain individuals of the colony the duty of bearing other and special buds possessing the

power of reproduction by means of ova.* This order of reproduction is usually described as "Alternation of generation," and this is the earliest instance of its occurrence in the animal kingdom. It is very important to realize these steps, more especially as they are to a great extent obscured in many instances. We will therefore enumerate them thus :

The "Alimentary" polypite. 1.—Alimentary Polypite. The ordinary colonial polypite, whose only duty is to obtain and assimilate food for itself and the colony, but which takes no part in the work of propagation.

The "Select" polypite. 1A.†—"Select" Polypite. Certain of the above, which, for reasons stated in the foot-note, we

* It is extremely interesting to note the parallelism with this order in the plant world. For example: Amongst the Ferns (Cryptogams), if one of the spores found on the back of a frond be sown, the result will not be a fern, but a very small and simple plant—a leafy expansion, called a prothalium. It is the function of this little plant to produce the male and female elements; and so soon as fertilization has taken place it dies leaving the embryos ("oo-spheres") to develop into proper ferns.

† The "Gonoblast" idea of Huxley and the "fertile polypite" of Hincks. Some apology seems necessary for presuming to suggest a more suitable term for these Buds, in

have called the "Select" Polypites, generally more or less modified or atrophied, whose special function is to produce—not eggs, but special buds of either sex, which, in the case of the females, do produce eggs.

"Reproductive" bud. 2. — Reproductive Buds ("Gonophores"). Those special buds, whose main function is the reproduction of the species by means of ova.

Modification of "Select" polypite. The important duties imposed upon the select polypites have been instrumental in more or less considerably modifying their original character as alimentary polypites; so much so, that in many species they have lost the tentacles, and even the mouth and stomach, and have become mere stumps. (**Loss of tentacles, mouth and stomach.**) Under these circumstances, it will be seen how very necessary for its maintenance, and for that of

the face of such authorities as the above-mentioned. These terms appear, however, to mislead, since both expressions unquestionably imply the seed or ova-bearing Buds. Now these are not the seed or ova-bearing Buds, but polypites which bear those Buds. The term "Select," or Selected, is free from this signification, and at the same time distinguishes these Buds from the ordinary alimentary polypites.

its future progeny, is the common supply of nutriment which it can always obtain, and which is kept circulating through the connecting channels of the colony.

Division of labour. We have here, in this "select" polypite a primitive example of the principle of division of labour; all its energies, in many cases, being devoted to its special function, just as the various cells of which our bodies are composed have their particular characteristics and special duties.

Specialised individuals. Among the hydroid colony the specialisation of individuals is not confined to the example previously stated. There are others whose functions are not so clearly understood (Hydractinia). Reference will be made to these in the description of the specimens.

Sexes of "reproductive" buds. At certain seasons of the year these "select" polypites throw out the reproductive buds. These on a given colony, may be either all male, or all female, or there may be some male and some female, but the former disposition is the more usual.

Two methods of dispersal. When these reproductive buds reach a certain stage of maturity, it will be found that two different methods of dispersal are adopted.

"Reproductive" buds either fixed or free. In one case, the buds (of either sex) become detached and migrate, fertilization taking place either before or after. In the other they remain attached. The ova are set free on the spot and disperse, and are termed "planulæ."

"Swimming-bell." In the first case (mainly obtaining amongst the lower forms), the young bud is liberated; it then assumes the condition known as the swimming-bell, and propels itself through the water by means of cilia, to which reference is made hereafter. The bud itself is essentially a polypite, that is to say, it possesses a typical mouth and stomach.

Development of the "bell." The animal in the region of the tentacles becomes greatly expanded laterally at the expense of that portion of the body below the tentacles, and now takes a cup or saucer-like form, overhanging the free, oval end of the animal.

A bell with a clapper will serve as an illustration. The clapper representing the polypite with the mouth at the free end, the bell corresponding exactly to the large expansion of the base. Sometimes there is a thin membrane partly closing the mouth of the bell called the "**veil.**"

Radiating canals. Opening out of the base of the stomach and traversing the bell radially, like the ribs of an umbrella, are four or more channels which extend to the margin of the bell and unite by running along it; this canal system serves to convey nutriment from the stomach to parts of the bell.

Channels, the homologue of tentacles. It has been conclusively shown that these radiating canals represent the polypital tentacles* which are formed after the same manner as the buds, *viz.*: by the simple process of inflation, thus producing long, tubular processes, which, in most polypites are closed, but in some are open.

The bud, therefore, in progressing through the water, strongly contracts the bell, and thereby expels the water, the re-action

*See *Clavatella*, Hincks' Brit. Hyd. Zoophytes, p. 70, *et seq.*

carrying it backwards.* The bell then resumes its original form and the process is repeated.

"Bell" and mouth tentacles armed with dart-sacks. To complete the description of the fully-developed free bud. Tentacles are sometimes formed around the mouth and also from the margin of the bell, from which they hang as long streamers, and are armed with powerful batteries of dart-sacks.

Secondary tentacles. In a few species which have not the bell fully developed and therefore are not so well fitted for swimming, the bell-tentacles throw out near their ends secondary tentacles, and these they use with which to walk as on stilts. Sometimes suckers are formed at their ends.

Organs for seeing. At the base of the bell-tentacles are little granular masses of pigment, generally of an orange colour, in some cases a crystalline body is embedded in

* Amongst the Molluscs, the Cuttle fish and others of its kind, progress after the same manner, and in a backward direction, by the sudden expulsion of water from a kind of pouch. Some bivalves, also, propel themselves by suddenly closing their valves and expelling the water.

them. To these organs the power of sight is attributed. In addition, along the margin of the bell there occur other organs which have more the appearance of eyes, very prominent and staring in character.

Lithocysts, organs of direction. These are little globular sacks containing a calcareous spherule, and are termed lithocysts. It was formerly thought that they might have been organs of hearing, but they are now regarded as organs of the sense of direction, in steering a course.

Nerves and Muscles. With regard to the nervous and muscular systems entailed by the development of the "bell" for swimming purposes. Romanes, in his work on "Jelly Fish, Starfish and Sea Urchins," gives an interesting account of experiments in dissection which he carried out on the Hydromedusæ, pointing conclusively to a differentiation of tissue in the direction of nerves and muscles.

Two rings of nerves. It is now, however, established, that there exists around the margin of the bell, two rings of nerves and nerve cells, one ring occurring just above and the other just below the "veil" process.

Primordial centralized nervous system. These rings afford the earliest example of a central nervous system in the animal world.

As to muscles, the whole inner surface of the bell is lined by fine cancellated muscular fibres. Muscular tissue also occurs in the "veil."

Primordial specialised excretory organs. In some species of these medusoid free buds, "pores" occur leading out of the marginal canal. These pores subserve excretion of whole matter and mark the earliest occurrence of special organs for this purpose amongst animals.

In this free bud, which we have cursorily described, with its "bell" and trailing tentacles, we are introduced to particular forms of creatures, which are well-known as Jelly-fish, but whose life-history is not so fully understood.*

*A distinction must, however, be made between the naked-eyed and covered-eyed Jelly-fish; the hydroid offspring corresponding to the former only, the latter being the offspring of the higher hydrozoans.

Jelly-fish hatches her eggs, then called "planulæ." The freed bud, or jelly-fish, after seeing something of the world of waters around it, may, in the case of a female, settle down, attach itself to some object, and ultimately give birth to a family, the members of which sooner or later disperse. They do not, however, in this, the larval stage, resemble either the polypite or their immediate parent the jelly-fish, but are little, flat, conical bodies called planulæ, which, in their later stages, enclose a cavity and swim by means of cilia.

"Planula" is modified into a polypite. Later on they attach themselves to some object by their larger end, which expands and divides into root-like filaments. A mouth and tentacles are formed at the upper end and the result is a polypite, similar to that which originated the colony. These polypites will then proceed to carry out the principle of continuous budding, and thereby form fresh colonies.

First method of dispersal. "Reproductive" bud bodily transported. This is one method by which the ova are

transported, *viz.:* by the mother-bud freeing herself from the colony and bearing the brood away to another place, and thus establishing a new centre of distribution.

Second method. Bud remains attached, ova set free. The reproductive buds in this case remain attached to the parent, fertilization takes place, and the ova (planulæ) are set free, disperse, and go through the same modifications as the planules of the detached buds, preparatory to establishing fresh colonies in the same manner.

"Select" and "Reproductive" buds nearly obliterated. The buds styled "select" and "reproductive," demand some further remarks. In many cases, their real identity as originating in distinct buds is almost wholly lost, and it is difficult to recognize any trace of bud unless it is known that a solution of the difficulty is to be found in certain links or intermediate forms. We will, therefore, set those interested in such matters at once on their guard. Hincks calls attention to these gradations, and his work on the Hydroids should be consulted by all who desire to study this group of animals.

Modification and atrophy of "select" bud. Beginning with the "select" polypite, that is to say, with the individual which displays the first step in the series of phenomena connected with reproduction. In the lower division (ATHECATA or naked polypites) some members which bear the gonophores are not modified at all, but in many species the tentacles become more or less aborted and the polypite stunted, and when the higher division (THECAPHORA or sheathed polypites) is reached the "select" polypites do not obtain nourishment from external sources, in fact, they have no mouths and are wholly unrecognizable as polypites.

There is, however, one exception in this division, amongst our British species, and that exception is the Genus HALECIUM, *Oken*, where the "select" polypites are fully developed, in other cases they are represented by a mere stump ("Blastostyle") bearing the reproductive buds In THECAPHORA, that which represents the "select" polypite is provided with a receptacle, fairly strong and modified to the special circumstances of the case. This modified receptacle is more in the nature of a case

or vessel because it contains not only the aborted "select" polypite, but also the reproductive buds bearing the ova. It is therefore termed a "capsule."

Modification and atrophy of "Reproductive" bud. In the ATHECATA and simpler THECAPHORES, the "reproductive" bud is generally a Medusa, but in some species of ATHECATA the bud remains attached.

In the THECAPHORA, however, we soon reach a certain point—the turning point—where, as in such cases as *Gonothyræa Lovéni*, *Allman*, liberation fails to take place and thenceforward the *fixed* bud is the distinguishing feature. The bud having now become a fixture, loses its individuality and the bell and tentacles dwindle away and the creature wastes down to a mere sack, which contains in its walls the ova. The bud, in both ATHECATA and THECAPHORA, is nearly always enclosed in a fine envelope, which eventually ruptures.

We have seen, therefore, in the final stages, the "Select" bud and the "reproductive" bud, both becoming obsolete, and almost all that remains ostensibly in their place, are the ova within the Capsule. Under

these circumstances, it is difficult to discriminate between these two buds, and it will therefore be convenient when this is the case, to suppress their individuality and to refer to the whole body as the egg-capsule, or simply, the capsule. Where, however, the "select" polypite is recognizable, as in ATHECATA, and is distinct from the reproductive bud, the latter with its envelope is also called the "gonophore."

Process of Budding, and Budding of Medusæ. The process of budding, as previously stated, is by inflations of the body wall, which is composed of an inner and an outer layer. This process takes place not only in the polypites, but also in the Medusæ, in which latter case the buds are Medusæ.

Ovaries are situated in body wall, also in radiating canals of Medusæ. Ova are formed between the outer and inner layers of the alimentary cavity. This is the case also in the Medusæ, but with some of these ova also occur in sacks (inflations of the layers) in the canals which radiate from the stomach cavity. The important distinction between budding and ova-production should therefore be clearly understood.

Larva is a "planule," a polypite, an Amœba, or a Medusa. Hincks states that in nearly all species the ova develop into planules, and thence become modified into polypites; but in the fresh water Hydra and a few other species, the ova at once take the form of polypites. One instance he cites in which the egg gives place to an amœboid form. There are some cases also, where the ovum of the hydroid-medusa does not revert to the fixed hydroid state but is hatched out a Medusa.

Hydroids compared with the sponges. Having briefly considered the nature of the Hydroids, a few remarks may not be out of place to state in what respect they differ from their neighbours on either side.

The group of organisms immediately below the Hydroids, is the Sponges. They are a peculiar and somewhat anomalous group of animals. It is difficult to define their actual affinities..

Suppose, however, we take a densely-branching hydroid, such as *Eudendrium rameum*, *Pallas* and deprive the animal colony

of the horny covering, and also of the *polypites*, leaving only the stem and branches, *i.e.*, a system of tubes or channels (cœnosarc), with their ends open. Let there now be developed between the inner and outer layer (of which the cœnosarc, like the polypite, is composed) a middle and a much thicker layer of simple flesh substance called protoplasm, containing, however, numerous "flesh particles" or cells. If we then picture the cilia throughout this canal system maintaining by their movements a constant circulation, not of partly assimilated nutriment as in the hydroid colony, but water containing food which is supplied it to all parts of the system; and furthermore, that the larger end of the main channel or central stem, into which all other channels eventually lead, be open forming an exit for the impoverished water, we shall gain an approximate idea of the comparative systems of a hydroid colony and a simple sponge.

As we go higher in the sponges, instead of the channel being lined with cilia and exercising stomachic functions, the cilia become restricted to little chambers lined by cells of peculiar form (collar cells), where also

probably food assimilation is localized, thus suggesting a comparison with the stomach of the polypite.

To complete the sponge simile. Instead of the horny tubing suited to the hydroid form, there is an intricate network of horny fibres, serving as a skeleton to support the otherwise somewhat flaccid body-substance, and in addition, the structure is rendered more solid by the secretion of minute needles of carbonate of lime or flint, in the flesh and fibre. These needles may be the homologue of the calcareous skeleton of some hydroids, *e.g.*, a foreign species of HYDRACTINIA and the fossil *Parkeria* and others.

Hydroids compared with the Sea-anemones and the coral polyps. Higher in the scale of development, above the Hydrozoa, are placed the Sea-anemones and the Coral polyps. In the hydroid animals the stomach is a simple sack, but in the anemones and coral polyps a slight though important transformation has taken place. It is first indicated in the higher medusæ. Instead of the simple sack-like stomach, the mouth portion is turned inwards. (*e.g.* A certain kind

of non-spilling inkstand). The preparation of food is carried on by this portion. The interior is called the body cavity, as distinct from the stomach.

Arising out of the body wall and directed towards the pendant stomach or centre of the animal, are certain little vertical fleshy plates (Mesenteries). The anemones do not possess these modifications, but the coral polyps do, and in addition secrete carbonate of lime, or horny coral, in the deposition of which the mesenteries take part, by secreting what are known as the "septa," or rays of the coral.

Hydroids and Polyzoa compared. There is so much outward similarity between these hydroid-zoophytes and certain other creatures of much higher standing, *viz.*, the Polyzoa and Bryozoa (Molluscoida) that it may be desirable to point out the wide gap which separates these two groups.

In appearance, they have much in common. They are very minute; they have the habit of permanent budding (thereby producing plant-like growths); they secrete a polypary-like covering; the animals themselves are transparent, and have a circle of tentacles

arranged round the mouth. On examination under the microscope, however, a considerable advance upon the structure of the hydroid will be observed. There is a well-formed through alimentary canal, entirely cut off from the body cavity, there is also a gizzard, and well-defined, though simple, muscular and nervous systems. The polypary, as it may be called, partakes to some extent, of a horny substance, but carbonate of lime also enters largely into the composition, more especially in the higher forms. The receptacle also, or cell of the polyzoan is more a part of the animal than is the case in the hydroids, where the whole polypary hangs like a loose-fitting garment on the compound animal, the former condition resembling more the relation of the shell to the shell-fish in the ordinary mollusc, to which the polyzoan is nearly allied.

TABLE C.

Systematic Table to show the position of the
HYDROMEDUSÆ (CRASPEDOTA)
(HYDROIDS, HYDROZOA, and HYDROIDA, of various Authors)
in the classification of the CŒLENTERATA.

PHYLUM CŒLENTERATA.

Radially symmetrical animals with only one cavity in the body —the gastrovascular space—which serves alike for digestion and circulation. The generative cells are always either ectodermal or endodermal.

Sub-phylum I. CNIDARIA.

Cœlenterata with thread-cells.

CLASS I. HYDROMEDUSÆ (CRASPEDOTA).

Cnidaria in which the medusa has a velum and the polyp is without gastral ridges or filaments.

Order 1. HYDRIDA.

Solitary polyps without medusoid buds. Both generative products are developed in the ectoderm of the polyp.

Order 2. HYDROCORALLINÆ.

Colonial Hydromedusæ, consisting of a meshwork of cœnosarcal canals, the ectoderm of which secretes a hard calcareous matter, filing up the spaces of the meshwork. Polyps of two forms, gastrozooids and dactylozooids. 2 Families.

Order 3. TUBULARIÆ (GYMNOBLASTEA).

Without hydothecæ and gonangia. Polyps, when more than one, forming permanent colonies. Generative individuals, when set free, are Anthomedusæ. 4 Sections. 14 Families.

ANTHOMEDUSÆ. The Medusæ of this Order.

Craspedota without otocysts, with ocelli at the base of the tentacles, and with manubrial gonads; radial canals, usually 4, rarely 6 or 8; budded from polyps of the Tubulariæ.

4 Families. 13 Sub-families.

Order 4. CAMPANULARIÆ (CALYPTOBLASTEA).

With hydrothecæ and gonangia. Colonial. Generative individuals, when set free, are Leptomedusæ.

4 Sections. 7 Families.

LEPTOMEDUSÆ. The Medusæ of this Order.

Craspedota partly with, partly without otocysts; ocelli present or absent, gonads on radial canals; budded from polyps of the Campanulariæ. 4 Families. 13 Sub-families.

Order 5. TRACHOMEDUSÆ.

Hydromedusæ without hydrosome (polyp stage); with marginal sense-tentacles in pits or vesicles, with endodermal otoliths. Ocelli usually absent. Gonads radial. Radial canals, 4, 6, or 8, often with centri-petal canals. With thread-cell thickening of ectoderm round the edge of the umbrella.

4 Families. 8 Sub-families.

Order 6. NARCOMEDUSÆ.

Craspedota with free auditory tentacles. Tentacles inserted dorsally on the ex-umbrella, and connected with its edge by peronium. Radial canals, when present, in the form of flat, radial, gastric pouches. 4 Families.

Order 7. SIPHONOPHORA.

Free-swimming polymorphic colonies of Hydromedusæ, produced by budding from an original, probably medusoid, individual. Gonads in gonophores, which, as a rule, are not set free.

Arranged by E. C. (After SEDGWICK).

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